US-PAT-NO: 5803985

DOCUMENT-IDENTIFIER: US 5803985 A

TITLE: Water fill sensing for a **dishwasher**

---------- KWIC ---------

A control system for a **dishwasher** (10) utilizing a turbidity sensor (24) to achieve an optimum fill cycle water level in a sealable chamber (12) into which soiled dishes are loaded. An electronically actuable fill valve (20) is controlled by a microprocessor (22) in response to signals received from the sensor (24) indicative of the turbidity of water in the chamber (12) during the fill cycle. Once turbidity of the water in the chamber stabilizes or drops to a predefined level, the fill water is determined to have reached an optimum level and the flow of supply water is shut off.

Water fill sensing for a **dishwasher**

This invention relates generally to cleansing appliances such as automatic dishwashers and, more particularly, to an improved sensor and method for efficiently controlling the amount of water provided in a **dishwasher** fill cycle.

The United States Department of Energy is currently in the process of setting higher efficiency standards which appliances such as washing machines and dishwashers will be required to meet by 1999. In view of greater concerns regarding energy consumption, as well as economic requirements of consumers, a greater focus has been put on energy efficiency in such home appliances. In

water handling cleansing machines such as clothes washers and dishwashers, the amount of energy consumed is primarily determined by the amount of energy needed to heat the water used to clean the articles. As an example, most of the energy consumed by a **dishwasher** is in heating the incoming water from the nominal home water supply temperature of 50.degree. F. to the required inlet temperature of 120.degree. F. Thus, reducing the amount of water used by a **dishwasher** during one or more cycles can be directly translated into energy savings.

A **dishwasher** typically receives water from a water supply into a sealed chamber into which dishes are loaded. An electronically controllable valve is used to turn the fill water OFF and ON. A microprocessor based control system is coupled to the fill valve as well as to other electronic system elements such as motors in order to effect the execution of wash cycles. A wash cycle generally includes providing substantially particle free water to the sealed chamber, circulating the water along with various additives such as detergent within the chamber and draining all or a portion of the water out of the chamber. This wash cycle can be followed by one or more rinse cycles where the same process is followed, except without detergent, and even may be preceded with a similar pre-wash cycle. In each type of cycle, generally the same procedure is followed. Water is supplied from the source into the chamber and an internal spraying device is provided for directing streams of water at the dishes to be washed.

As the chamber continues to be filled with water, cavitation substantially diminishes or ceases. This occurs primarily because the pump eventually

receives a sufficient amount of water to be able to pump the water in a continuous stream. By monitoring the level of cavitation and using that information to determine a point in time wherein cavitation substantially decreases or approaches cessation, an appropriate but not excessive fill level can be determined. To accomplish this, the level of turbidity is monitored through the fill process. When the amount of turbidity decreases below a certain predetermined level or reaches a certain level of stability, a signal from the turbidity sensor indicates to the **dishwasher** controller that a sufficient amount of water has been received and that the controller should signal the fill valve to close.

This provides an improved method of effectively controlling the amount of water added to a **dishwasher** during each fill cycle. It also takes advantage of a growing availability of turbidity sensors already existing in dishwashers. These sensors provide an "eye" into the wash chamber and are most commonly used to provide the controller with information regarding soil levels during wash cycles in order to optimize cleaning time.

FIG. 1 is a partially cut away perspective view of a **dishwasher** controlled using the system of the present invention.

FIG. 2 is a graph illustrating turbidity sensor readings produced by the **dishwasher** shown in FIG. 1 and controlled according to the method of the present invention.

Turning now to the drawings, and in particular to FIG. 1, a **dishwasher** having a control system made in accordance with the present invention is indicated generally at 10. **Dishwasher** 10 includes a wash chamber 12 into which

dishes and the like may be loaded, chamber 12 being sealable and having a sump 14 formed in the bottom thereof. Disposed in sump 14, or at least fluidly connected therewith, is a motor driven pump (not shown) which is also fluidly connected to a spray device 18 for distributing water pumped by the pump throughout the chamber 12. An electronically actuable inlet valve 20 is operable to permit and prohibit the flow of water from a supply into the wash chamber. Valve 20 is electrically connected to a microprocessor-based controller 22 as is a turbidity sensor 24.

Thus, the present invention provides a **dishwasher** control system and method useful for optimizing the amount of water supplied to a wash chamber during a water fill cycle. The use of the turbidity sensor, a device being implemented more commonly in dishwashers to create "smart" appliances, further increases energy efficiency and eliminates any need for other similar sensors such as floats or level sensors.

3. The method of claim 2 wherein said appliance is an automatic **dishwasher**.

134/18

US-PAT-NO: 5408716

DOCUMENT-IDENTIFIER: US 5408716 A

TITLE: Fluid-handling machine incorporating a closed loop system for controlling liquid load

DATE-ISSUED: April 25, 1995

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Dausch; Mark E.	Latham	NY	N/A	N/A
Badami; Vivek V.	Schenectady	NY	N/A	N/A
Whipple, III; Walter	Amsterdam	NY	N/A	N/A

US-CL-CURRENT: 8/158, **134/18** , 134/25.2

CLAIMS:

What is claimed is:

1. A method for cleansing articles by utilizing a machine including means for distributing liquid in said machine, said method comprising the steps of:

(a) providing said liquid to said machine;

(b) distributing said liquid in said machine as said machine receives said liquid;

(c) detecting liquid pressure oscillations in said liquid as said machine distributes said liquid; and

(d) shutting off flow of said liquid provided to said machine when the

detected liquid pressure oscillations substantially cease in accordance with a
fuzzy logic feedback control strategy based upon:

(i) elapsed time for distributing said liquid;

(ii) an amplitude of the detected liquid pressure oscillations; and

(iii) an average slope of the detected liquid pressure oscillations.

2. The method of claim 1, wherein the step of detecting liquid pressure
oscillations comprises the step of measuring the pressure of said liquid.

3. The method of claim 1, wherein the step of detecting liquid pressure
oscillations comprises the step of measuring changes in the pressure of said
liquid.

4. The method of claim 1, wherein the step of detecting liquid pressure
oscillations comprises measuring the flow rate of said liquid.

5. The method of claim 1, wherein the step of detecting liquid pressure
oscillations comprises measuring changes in the flow rate of said liquid.

6. A method for cleansing articles by utilizing a machine including means
for distributing liquid in said machine, said method comprising the steps of:

(a) providing said liquid to said machine;

(b) distributing said liquid in said machine as said machine receives said
liquid;

(c) detecting liquid pressure oscillations in said liquid as said machine
distributes said liquid; and

(d) controlling the amount of liquid provided to said machine in accordance with a fuzzy logic feedback control strategy so that the flow of said liquid provided to said machine is shut off when said liquid pressure oscillations substantially dampen out, said fuzzy logic feedback control strategy being based upon:

(i) elapsed time for distributing said liquid;

(ii) an amplitude of the detected liquid pressure oscillations; and

(iii) an average slope of the detected liquid pressure oscillations.

7. The method of claim 6, wherein the step of detecting liquid pressure oscillations comprises the step of measuring the pressure of said liquid.

8. The method of claim 6 wherein the step of detecting liquid pressure oscillations comprises the step of measuring changes in the pressure of said liquid.

9. The method of claim 6, wherein the step of detecting liquid pressure oscillations comprises measuring the flow rate of said liquid.

10. The method of claim 6, wherein the step of detecting liquid pressure surges comprises measuring changes in the flow rate of said liquid.

11. The method of claim 6, wherein the amount of liquid provided to said machine is controlled so that enough liquid is provided to cause said liquid pressure oscillations to substantially dampen out.

US-PAT-NO: 4509543

DOCUMENT-IDENTIFIER: US 4509543 A

TITLE: Industrial **dishwasher** monitor/controller with speech capability

---------- KWIC ----------

A **dishwasher** monitor/controller for monitoring the operation of a **dishwasher** and providing human-intelligible speech messages upon the detection of predefined fault conditions. The operation of the **dishwasher** is periodically monitored using temperature measurements, water conductivity measurements, detection of the absence of drying agent, and timers to measure how long various physical conditions continue between periodic maintenance procedures. The **dishwasher** faults detected include directly tested faults and indirectly (elapsed-time dependent) tested faults. The direct tests for faults are for low rinse water temperature, low wash water temperature, and absence of drying agent. The indirect tests are for dirty wash water, absence of detergent, and the need to inspect the interior of the washer for dirt and calcium carbonate scale build-up. Furthermore, there is provided a switch activated facility for orally explaining, step-by-step, how to properly start-up the **dishwasher** and how to shut it down.

Industrial **dishwasher** monitor/controller with speech capability

This invention relates generally to dishwashing machines and more particularly to a monitor/control apparatus and method for

use in conjunction
with an industrial **dishwasher** and its detergent and drying agent pumping
apparatus.

Prior art monitor and control apparatus for industrial dishwashers have had
the capability of monitoring wash and rinse water temperature, for monitoring
the amount of detergent added and for detecting the absence of detergent and
drying agent. For each error condition there is usually a corresponding light
on a panel and possibly a corresponding beep or tone from a small noise
generator. These prior art machines, however, have not had the ability to
determine when the wash water should be changed or when the machines should be
inspected for scale formation buildup. Furthermore, the warning lights and
beeps are sometimes considered confusing by the person running the **dishwasher,**
who may not bother to look closely at the panel to determine which warning
light is on, and are also easily ignored.

Another problem with prior art machines relates to the training of new
personnel to operate the machine. There is often a high turnover rate among
the people employed as dishwashers. Also, written instructions for operating
the machine, especially for turning the machine on and for turning it off, are
read mostly by managers. **Dishwasher** operators are usually instructed on these
procedures orally a couple of times and then are expected to remember what to
do. If the operator forgets what to do or the order of the steps to be
followed, the **dishwasher** may not operate properly and the dishes in the
dishwasher will not be sanitized.

These two timers make use of an indirect measurement, rinse-water-pump-time,
corresponding to how much the machine has been used. They

help insure that
periodic maintenance procedures necessary for producing sanitized dishes and
maintaining the integrity of the **dishwasher** are followed.

FIG. 1 depicts a **dishwasher** machine and the monitoring and control equipment
attached thereto.

Referring to FIG. 1 there is shown a block diagram of a **dishwasher** system 11
in accordance with the present invention. The **dishwasher** 12 can be any one of
several commercially sold industrial dishwashers. Therefore, the **dishwasher** 12
can be either of the batch type or the conveyorized type. In either type of
dishwasher 12 the dishes are first subjected to a flow of wash water for a
period typically ranging between forty-five seconds and one minute thirty
seconds and are then subjected to rinse water for a period typically ranging
between ten seconds and thirty seconds. In a batch type of **dishwasher** 12 one
or more trays 13 of dishes are placed inside **dishwasher** 12 and then subjected
to a wash cycle and then a rinse cycle and are then removed before the next set
of dish trays 13 is washed. In a conveyorized **dishwasher** 12 trays of dishes
travel on a conveyor through two sections: a wash section and then a rinse
section. The monitor and controller system 31 described below is designed for
use with either type of system, and distinctions between these two types of
dishwashers 12 is generally not relevant herein.

The water used in the wash cycle is generally recycled water held in a water
tank 20 below the trays of dishes 13. Thus the dishes being cleaned are
initially sprayed, using sprayer arms 14a and 14b above and below the dishes,
with water from the water tank 20 that has been used before. The wash water

contains a predetermined amount of detergent for sanitizing the dishes. The water used to rinse the dishes is clean, hot water sprayed on the dishes using sprayer arms 15a and 15b which are concentrically mounted with the sprayer arms for wash water 14a and 14b. The wash water sprayer arms 14a and 14b and the rinse water sprayer arms 15a and 15b have completely distinct plumbing (not shown in FIG. 1). The rinse water is clean fresh water which is preheated using a water heater 16. When it is time to rinse the dishes a solenoid 17 is activated by the **dishwasher** 12 thereby allowing water to flow into the rinse sprayer arms 15a and 15b. As the rinse water flows into the **dishwasher** 12 a drying agent is drawn from a container 18 by means of a motor or pump 19 and is added to the flow of rinse water in rinse water line 24. The drying agent, as its name indicates, facilitates the drying of the dishes after they are removed from the **dishwasher** 12 and helps prevent spotting.

The water tank 20 below the dish trays 13 typically holds approximately fifteen gallons of water per tray of dishes processed by the **dishwasher**. As water is added to the tank 20 during the rinse cycle the tank 20 overflows into overflow line 23. The wash water tank 20 also contains an immersible heater 21 for heating the wash water when the **dishwasher** 12 is first started up and also for maintaining the wash water at a temperature sufficient to sanitize dishes. The **dishwasher** 12 typically has a temperature control 22 for setting the temperature of the water in wash tank 20.

The monitor and controller apparatus 31 of the present invention is connected to the **dishwasher** 12 as follows. First, it is connected to thermistor 32 in the wash tank 20 for determining the temperature of the wash

water. It is also connected to two probes 33 in the wash tank 20 which are a predetermined distance from one another and which are used to determine the resistivity or conductivity of the wash water. This resistivity or conductivity measurement can be used to determine the amount of detergent in the water and also to determine if the wash tank 20 is empty or full. Next, the monitor 31 is connected to a thermistor 34 in the rinse water line 24 to determine the rinse water temperature. Also the monitor is connected to a pressure switch 35 which detects increases in pressure in the rinse water line 23. The monitor 31 is connected to the drying agent pump or motor 19 both for the purpose of detecting the speed of the motor 19 and also for controlling that speed. The monitor 31 is connected to a vacuum switch 36 connected to the drying agent feed line 27 for detecting the absence of drying agent in container 18. Similarly, the monitor 31 is connected to the motor or solenoid 28 which controls the addition of detergent to the wash water in tank 20 from detergent dispenser 29. The motor or solenoid 28 is a pump if the detergent is a fluid and is a solenoid with a mixing mechanism if the detergent is a dry chemical.

The monitor and controller 31 has a set of lights 36, each corresponding to different potential problems and the proper operation of the **dishwasher** 12. A series of dials 37 are used to select several parameter values described below for controlling the operation of the monitor controller 31. The two-position center-position-off switch 38 is used by the operator of the **dishwasher** 12 for obtaining instructions on how to start-up the **dishwasher** 12 and how to shut it off. Finally, a speaker 39 transmits messages to the operator of the

dishwasher 12 when any one of a set of predefined faults or error conditions is
detected by the monitor/controller 31.

Referring to FIG. 2 there is shown a block diagram of the **dishwasher**
monitor/controller 31. The major components of the monitor/controller 31 are a
microprocessor 41, which is an 8039 made by Intel in the preferred embodiment;
an 8k.times.8 EPROM (electrically programmable read only memory) which is a
2764 made by Texas Instruments in the preferred embodiment;
a speech chip 43,
which is a 5220 made by Texas Instruments in the preferred embodiment; and an
analogue to digital converter (ADC) 44. The microprocessor 41 is connected to
most of the elements of the monitor/controller 31 by a bus 45, which is eight
bits wide.

Input signals from the **dishwasher** 12 and its associated monitoring equipment
fall into basically two categories: on/off signals and qualitative signals.
The on/off signals are buffered by buffer 51 which then transmits them onto the
bus 45. These signals are: drying agent prime 51a (prime drying agent pump
19), rinse pressure 51b, drying agent vacuum 51c, start-up 51d, shutdown 51e,
and washer on/off 51f.

The other qualitative input signals reflect the conditions in the **dishwasher**
12 and the speed of the drying agent pump motor 19.
Analogue input 44d is
connected to the wash water temperature thermistor 32 which generates a voltage
value corresponding to the temperature of the wash water in the wash tank 20.
Analogue input 44e is connected to the rinse water temperature thermistor 34.
Analogue inputs 44f and 44g are derived from measurements of the conductivity
of the water in the wash tank 20. A sampler circuit 52 creates pulses which

are capacitively coupled to the wash water conductivity probes 33. The resulting voltage across the conductivity probes 33 is proportional to the resistivity of the water in the wash tank 20. The resistivity of the wash water is tested in two different resistivity ranges by the sample circuit 52. The first range of resistivity values is the range normally associated with different levels of detergent in the water. A second range of higher resistivity values is used to distinguish between clean wash water from an empty wash tank 20. Input signal 44h is proportional to the speed of the drying agent pump motor 19. If the speed of the motor 19 is greater than the value determined by speed set circuit 53 the input signal 44h is in one range; if it is close to or equal to the predetermined speed it is in a second range, and if it falls below the predetermined speed the signal 44h is in a third range. Drying agent motor control 54 uses a standard post and pedestal technique for controlling the speed of the drying agent pump motor 19. When rinse prime signal 51a is "on" the monitor/controller 31 activates the drying agent pump motor 19 until the signal 51a goes "off". This fills the drying agent feed tube 27, as required for proper operation.

The **dishwasher** monitor/controller 31 operates as follows. During normal operation the main task of the monitor/controller 31 is to monitor the various input signals and to control the two motors 19 and 28 for drying agent and detergent. The drying agent pump motor 19 is activated whenever clean rinse water is flowing into the **dishwasher** 12. The flow of rinse water is detected by a pressure switch 35 connected to the rinse water feed line 24. The relatively high pressure on the rinse water feed line 24 when the solenoid 17

is open, compared to when it is closed and the rinse water is not flowing, is used by the pressure switch 35 to provide a rinse on/off signal 51b for use by the microprocessor 41. The speed of the drying agent pump motor 19 is selected by adjustment of speed set 53 which is basically a pot resistor that controls the gain of an op-amp. The drying agent motor control 54 works by transmitting only that fraction of the full wave rectified (but unfiltered) twenty-four volt supply waveform necessary to produce the selected motor speed.

The rinse water temperature is measured and compared against its selected set value whenever the **dishwasher** 12 is on (signal 51f). If the measured temperature falls below the selected minimum value, a corresponding warning light 36 is turned on and a speech message is generated.

The presence of drying agent is detected by use of a vacuum switch 36 on the drying agent feed line 27. A yes/no signal is sent by the vacuum switch 36 periodically whenever the **dishwasher** is turned on. The relative "vacuum" in the drying agent feed line 27 is caused by the gravitational pressure on the liquid in feed line 27 which is vertically displaced over the drying agent container 18 and under the drying agent pump 19 (which in the preferred embodiment must be at least twenty-four inches higher up than the container 18 to ensure proper operation of the vacuum switch 36). When the drying agent feed line 27 is not quite empty, but only has a small amount of drying agent (e.g., 12 inches of feed tube 27 volume) therein, the vacuum switch 36 will detect the "absence" of drying agent, thereby providing warning of the need to add more drying agent slightly before the supply is actually exhausted.

The first indirect test is for the presence of detergent in the detergent container 29. Whenever the **dishwasher** is on (i.e., washer on/off signal 51f is "on") and the wash tank 20 is not empty (see discussion above), the concentration of detergent in the wash tank 20 is measured by measuring the resistivity of the wash water. If the resistivity is higher than the value selected by the installer (sampler circuit 52 input 52a)--which corresponds to a selected concentration of detergent in the wash tank 20--the microprocessor 41 turns on the detergent motor/solenoid 28 to add detergent to the wash tank 20.

The maximum amount of time allowable between replacements of the wash water is set by the installer of the monitor/controller 31 using the pot-dial 37 corresponding signal input 44a. The idea here is that an attentive **dishwasher** operator will periodically check the dirtiness of the wash water and will purge and replace it before the maximum wash water usage time elapses. But if the operator does not do so, then the monitor/controller 31 will turn on a warning light 36 and will transmit an oral message via speaker 39 warning of the problem and explaining what to do.

The third indirect test also measures the amount of time the drying agent pump motor 19 is used. Its purpose is to periodically remind the **dishwasher** operator to periodically inspect the **dishwasher** rinse arms and the insides of the tank for excessive build-up of calcium carbonate scale. This inspection is best done when the wash tank 20 is empty. Also this inspection need not be performed every time the wash tank 20 is purged. Therefore, in the preferred embodiment the drying agent motor 19 time is accumulated until twice the

maximum wash water replacement time has passed. Then, the next time the monitor/controller 31 detects that the wash tank 20 is empty it transmits a message over the speaker 39 reminding the operator to perform the required inspection. Upon broadcast of this message the timer is reset to zero.

The start-up and shutdown instruction sequences can be used both for training purposes and for helping substitute personnel filling in for the usual **dishwasher** operator. Generally, though, this facility will probably not be used once the **dishwasher** operator has gone through the sequence two or three times.

1. In a **dishwasher** system having rinse water receiving means, detergent receiving means and detergent dispensing means, and wash tank means for holding a quantity of water, monitor/controller apparatus comprising:

rinse water detection means for detecting when water is flowing through said rinse water receiving means into said **dishwasher**; and

instruction means, including switch means for activating said instruction means, and means for sequentially generating predetermined instruction speech messages in response to sequential signals from said switch means, wherein said instruction speech messages contain words explaining how to operate said **dishwasher** system.

US-PAT-NO: 5800628

DOCUMENT-IDENTIFIER: US 5800628 A

TITLE: Continuous cycle operation for dishwashers using turbidity sensor feedback

DATE-ISSUED: September 1, 1998

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Erickson; Timothy K.	Lena	IL	N/A	N/A
O'Brien; Gary R.	Freeport	IL	N/A	N/A

US-CL-CURRENT: **134/18**, 134/25.2 , 134/56D , 134/57D , 134/58D , 68/12.02

CLAIMS:

The embodiments of the invention in which an exclusive property or right is claimed are defined as follows:

1. A method for washing an object, comprising:

providing a container;

disposing said object within said container;

starting a first washing cycle by providing an initial quantity of water within said container, said cycle being the period from fill to near complete drain of said water in said container;

causing said water to contact the surface of said object;

periodically measuring the turbidity of said initial

quantity of water while
said water is being caused to contact said surface of said object to provide a
series of turbidity measurements over time;

calculating a first magnitude of a first turbidity characteristic from said
turbidity measurements of said initial water quantity;

removing a first portion of said initial quantity of said water from said
container to obtain a remaining portion, said first portion being less than
said initial quantity;

measuring the turbidity of said remaining portion;

calculating a second magnitude of said first turbidity characteristic from
said turbidity measurement of said remaining portion; and

determining the degree and character of particulates within said water as a
function of the difference between said first and second magnitudes of said
first characteristic of said turbidity measurements; and

based upon said determination of degree and character, either removing from
the container a second portion of the remaining portion, removing from the
container all of the remaining portion, or proceeding with the remaining
portion contacting the surface of the object.

2. The method of claim 1, further comprising:

adding clean water to said container to compensate for said removed first
portion of said initial quantity of said water, said adding step being
performed before measuring the turbidity of the remaining portion.

3. The method of claim 1, further comprising:

calculating a first magnitude of a second characteristic of said turbidity

measurements of said initial water quantity; and

calculating a second magnitude of said second characteristic of said turbidity measurement from said remaining portion.

4. The method of claim 3, further comprising:

calculating a first magnitude of a third characteristic of said turbidity measurements of said initial water quantity; and

calculating a second magnitude of said third characteristic of said turbidity measurement from said remaining portion.

5. The method of claim 4, further comprising:

calculating a first magnitude of a fourth characteristic of said turbidity measurements of said initial water quantity; and

calculating a second magnitude of said fourth characteristic of said turbidity measurement from said remaining portion.

6. The method of claim 1, wherein:

said first characteristic is a measurement of said turbidity of said water.

7. The method of claim 3, wherein:

said second characteristic is a rate of change of said turbidity of said water over time.

8. The method of claim 4, wherein:

said third characteristic is a measurement of the degree of variability of said turbidity of said water over time.

9. The method of claim 5, wherein:

said fourth characteristic is a measurement of the rate of change of the degree of variability of said turbidity of said water over

time.

10. The method of claim 1, wherein:

said first characteristic of said turbidity comprises one of a group
consisting of: the turbidity of said water, a rate of change of said turbidity
of said water over time, a degree of variability of said turbidity of said
water over time, and a rate of change of said degree of variability of said
turbidity of said water over time.

11. The method of claim 1, wherein:

said container is disposed within a **dishwasher** and said object is a dish.

12. The method of claim 1, wherein:

the steps of said method are performed in the order shown in claim 1.

13. A method for washing an object, comprising:

providing a container;

disposing said object within said container;

starting a first washing cycle by providing an initial quantity of water
within said container, said cycle being the period from fill to near complete
drain of said water in said container;

causing said water to contact the surface of said object;

periodically measuring the turbidity of said initial quantity of water while
said water is being caused to contact said surface of said object to provide a
series of turbidity measurements over time;

calculating a first magnitude of a first turbidity characteristic from said
turbidity measurements of said initial water quantity;

calculating a first magnitude of a second turbidity characteristic from said
turbidity measurements of said initial water quantity;

removing a first portion of said initial quantity of said water from said
container to obtain a remaining portion, said first portion being less than
said initial quantity;

measuring the turbidity of said remaining portion;

calculating a second magnitude of said first turbidity characteristic from
said turbidity measurement of said remaining portion;

calculating a second magnitude of said second characteristic of said
turbidity of said remaining portion;

determining the degree and character of particulates within said water as a
function of the difference between said first and second magnitudes of said
first characteristic of said turbidity measurements; and

adding clean water to said container to compensate for said removed first
portion of said initial quantity of said water, said adding step being
performed before measuring the turbidity of the remaining portion; and

based upon said determination of degree and character, either removing from
the container a second portion of the remaining portion, removing from the
container all of the remaining portion, or proceeding with the remaining
portion contacting the surface of the object.

14. The method of claim 13, further comprising:

calculating a first magnitude of a third characteristic of said turbidity
measurements of said initial water quantity; and

calculating a second magnitude of said third characteristic of said turbidity measurement from said remaining portion.

15. The method of claim 14, further comprising:

calculating a first magnitude of a fourth characteristic of said turbidity measurements of said initial water quantity; and

calculating a second magnitude of said fourth characteristic of said turbidity measurement from said remaining portion.

16. The method of claim 13, wherein:

said first characteristic is the turbidity of said water.

17. The method of claim 13, wherein:

said second characteristic is a rate of change of said turbidity of said water over time.

18. The method of claim 14, wherein:

said third characteristic is a degree of variability of said turbidity of said water over time.

19. The method of claim 15, wherein:

said fourth characteristic is a rate of change of the degree of variability of said turbidity of said water over time.

20. A method for washing an object, comprising:

providing a container;

disposing said object within said container;

starting a first washing cycle by providing an initial quantity of water within said container, said cycle being the period from fill to near complete drain of said water in said container;

causing said water to contact the surface of said object;

periodically measuring the turbidity of said initial quantity of water while said water is being caused to contact said surface of said object to provide a series of turbidity measurements over time;

calculating a first magnitude of a first turbidity characteristic from said turbidity measurements of said initial water quantity;

calculating a first magnitude of a second turbidity characteristic from said turbidity measurements of said initial water quantity;

removing a first portion of said initial quantity of said water from said container to obtain a remaining portion, said first portion being less than said initial quantity;

measuring the turbidity of said remaining portion;

calculating a second magnitude of said first turbidity characteristic from said turbidity measurement of said remaining portion;

calculating a second magnitude of said second characteristic of said turbidity of said remaining portion;

determining the degree and character of particulates within said water as a function of the difference between said first and second magnitudes of said first characteristic of said turbidity measurements; and

based upon said determination of degree and character, either removing from the container a second portion of the remaining portion, removing from the container all of the remaining portion, or proceeding with the remaining portion contacting the surface of the object;

calculating a first magnitude of a third characteristic of said turbidity
measurements of said initial water quantity;

calculating a second magnitude of said third characteristic of said
turbidity measurement from said remaining portion;

calculating a first magnitude of a fourth characteristic of said turbidity
measurements of said initial water quantity;

calculating a second magnitude of said fourth characteristic of said
turbidity measurement from said remaining portion; wherein

said first characteristic is turbidity of said water;

said second characteristic is a rate of change of said turbidity of said
water over time;

said third characteristic is a degree of variability of said turbidity of
said water over time;

said fourth characteristic is a rate of change of the degree of variability
of said turbidity of said water over time; and

adding clean water to said container to compensate for said removed first
portion of said initial quantity of said water, said adding step being
performed before measuring the turbidity of the remaining portion.

US-PAT-NO: 6007640

DOCUMENT-IDENTIFIER: US 6007640 A

TITLE: Method for using a turbidity sensor to interrupt drain motor and water valve

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The **dishwasher** of the present invention is adapted to skip a drain cycle if the water in the **dishwasher** is clean enough. The invention uses a turbidity sensor to sense the turbidity of the water. If the sensed turbidity is below a threshold value, the drain motor and the water valve are disabled to prevent the water from being drained and to prevent additional water from being introduced into the **dishwasher**.

A typical **dishwasher** includes a washing chamber having side walls, a top wall, a bottom wall, and a wash water circulation system mounted in the bottom wall of the washing chamber. The water circulation system pumps wash water upwardly through a lower rotating wash arm and downwardly through an upper rotating wash arm for spraying water onto the dishes and other articles to be cleaned within the washing chamber. Typically, at the end of each wash or rinse cycle, the water is drained from the washing machine and new water is used during the next cycle.

Various prior art dishwashers use turbidity sensors to sense the cleanliness of the water during a wash or rinse cycle. The sensed turbidity is then used in some manner to control the operation of the **dishwasher**.

A general feature of the present invention is the provision of a method and apparatus for providing a control system for a **dishwasher** which overcomes problems found in the prior art.

A further feature of the present invention is the provision of a method and apparatus for providing a control system for a **dishwasher** which uses a turbidity sensor to determine the cleanliness of the water after a cycle, and, upon detecting a level of turbidity below a threshold level, interrupts power to the drain and to the water valve, preventing water from draining from, or overfilling the **dishwasher**.

A method and apparatus for providing a control system for a **dishwasher** which prevents the **dishwasher** from overflowing by preventing energization of the water valve if the float (water level sensor) malfunctions when the turbidity sensor interrupts a drain, or when a drain cycle is skipped.

A method and apparatus for providing a control system for a **dishwasher** which uses a turbidity sensor and a relay connected to the sensor for preventing the drain winding of the motor from being energized under certain conditions.

The control system of the present invention is used in a **dishwasher** to skip a drain cycle if the water within the **dishwasher** is clean enough. The control system includes a drain motor for draining water from the **dishwasher,** a water valve for selectively introducing water into the **dishwasher,** and a turbidity sensor. The turbidity sensor senses the level of turbidity of the water in the **dishwasher** and disables the drain motor and the water valve if the sensed level of turbidity is below a threshold value.

FIG. 1 is a perspective view showing a **dishwasher** of the present invention.

FIGS. 3A-3B show a timing diagram illustrating the operation of the **dishwasher** of the present invention.

FIG. 1 shows a **dishwasher** 10 including an access door 12 pivotally movable between an open position and the closed position shown in FIG. 1. The **dishwasher** 10 includes side walls, a bottom wall, and a top wall, which together with the access door 12 define a washing chamber. FIG. 1 also shows a control panel including a selector switch 14 which is used by a user to select from various operating modes. Disposed within the washing chamber is a pump assembly for circulating water throughout the **dishwasher** 10. The above described structure of the **dishwasher** 10 is conventional and does not, by itself, form a part of the present invention.

FIG. 2 is an electrical schematic diagram of the present invention. Among other components, the diagram in FIG. 2 shows the selector switch 14, a timer 16, a **dishwasher** motor 18 (including main, drain, and wash windings), a turbidity sensor 20, a water valve 22, and a float switch 24.

In general, the various cycles in the **dishwasher** 10 include the following sequence of steps: fill, circulate, drain, fill, etc. In order to save water in the **dishwasher** 10, the turbidity sensor 20 is used to sense the cleanliness of the water or quantity of particulate matter in the water after a water circulation period. If the sensed water is clean enough, the next drain cycle is skipped so that the same water can be used again. In order to accomplish

this, the turbidity sensor 20 is capable of interrupting the power to the motor 18 (therefore interrupting the power to the drain) so that the same water can be used for the next circulation period. As mentioned above, the turbidity sensor 20 is connected to the motor 18 as well as the water valve 22. When a drain is skipped if the sensed water is clean enough, the sensor 20 interrupts power to the drain winding of the motor 18 which prevents the drain winding from being energized. In addition, the turbidity sensor 20 will also hold the water valve 22 open so that additional water may not enter the **dishwasher** 10, should the timer contact or the float switch 24 be stuck. Without controlling the water valve 22, the **dishwasher** 10 could overflow if the drain is skipped and the float switch 24 malfunctions. By controlling the water valve 22 during a skipped drain, the system becomes more reliable. The turbidity sensor closes the circuit to the drain winding of motor 18 and the water valve 22 after the timer 16 has advanced into the next circulating period.

If the **dishwasher** 10 uses a timed fill and a float switch backup, the present invention keeps the **dishwasher** from overfilling. If the **dishwasher** 10 uses a float switch to fill and a timer as a back up, the present invention also keeps the **dishwasher** from overfilling, in case the float 24 becomes stuck or otherwise malfunctions.

FIGS. 3A and 3B illustrate a timing diagram of the operation of the present invention. As shown in FIG. 3A, the turbidity sensor 20 affects the operation of the **dishwasher** 10 during the time periods shown. If either of the drain cycles are skipped, the turbidity sensor 20 will prevent the drain winding from energizing, and will disable the water valve 22.

To start the selected operating mode, the **dishwasher** will fill with water.
The filling will stop either when the float switch 24 is tripped, or after a
predetermined time interval, depending on the particular **dishwasher** used. Once
the **dishwasher** 10 is filled, a water circulation cycle will begin (e.g., rinse
or wash, etc.). After the circulation period, the turbidity sensor 20 will
sense the cleanliness of the water in the **dishwasher** 10. If the water is dirty
enough, the **dishwasher** 10 will drain the water and fill with clean water for
the next cycle, as illustrated in the timing diagram in FIGS. 3A-3B. If the
sensed water is clean enough, the water will be reused during the next
circulation period. In this case, the turbidity sensor 20 will also disable
the drain winding of the motor 18 and will disable the water valve 22. The
water within the **dishwasher** 10 therefore will not drain and additional water
will be prevented from entering the **dishwasher,** preventing any overfilling.
The subsequent circulation period then commences using the same water that was
used in the previous circulation period.

1. A method for controlling a **dishwasher** comprising:

filling said **dishwasher** with a predetermined amount of washing fluid through
a fill valve, said fill valve being convertible from an enabled condition
permitting said fluid to enter said **dishwasher** to a disable condition
preventing said fluid to enter said **dishwasher;**

spraying said washing fluid onto objects to be washed within said
dishwasher;

actuating said drain pump to remove said washing fluid from said **dishwasher**
and placing said fill valve in said enabled condition to

refill said **dishwasher**
if said sensed turbidity of said washing fluid is above a threshold value; and

2. A method according to claim 1 and further comprising using a float valve
to sense the level of said washing fluid within said **dishwasher** and placing
said fill valve in said disabled condition in response to said float valve
sensing that the level of said washing fluid within said **dishwasher** is above a
predetermined level.